



## Is R&D Enough to Take Advantage From External Knowledge? Focusing on Coordination Mechanisms

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### Abstract

The purpose of this paper is to analyze the role of research and development (R&D) and coordination mechanisms (such as decentralization in decision-making and formalization of organizational processes) in the transformation of external knowledge into innovation results. We use survey data for performing standard ordinary least squares regressions in a representative sample of firms from the Spanish Ceramic Tile Industry. The results suggest that R&D is an important moderator influencing the relationship between acquiring external knowledge and innovation outcomes. Second, formalization tends to have a detrimental effect in the transformation of external knowledge into innovation outputs. Third, there are differences if it is discriminated between exploratory and exploitative innovations. This study contributes to external knowledge sourcing research that insofar has only taken account of R&D, neglecting the role of coordination mechanisms, in the exploitation of this knowledge. Moreover, this study is relevant to organization theory. To date, this literature has focused on the direct effect of coordination mechanisms on innovation. We show that the latter can be contingent on external knowledge processes. Lastly, we add to both literature streams by showing the different nature of the results when considering exploratory or exploitative innovations.

**Keywords:** external knowledge sourcing; formalization; decentralization; r&d; exploratory innovation; exploitative innovation.

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## Introduction

Innovation is central in establishing and sustaining competitive advantage of firms (Nelson, 1991; Baer, 2012). The evolution of an increasingly complex environment has placed innovation as an indispensable option when planning to increase firms' performance and assure its growth and ultimate survival (Damanpour, 1991; Tellis et al., 2009). A range of research approaches, such as evolutionary, innovation network and open innovation theorists, underscore the increasing importance of interactions between organizations and external agents in the achievement of innovative results (Breschi and Malerba, 1997; Baptista and Swann, 1998; Chesbrough, 2003; Martin-de-Castro et al., 2011). Some even emphasize that external knowledge has become more important than traditional knowledge produced through inhouse R&D (Chesbrough, 2003; Rass et al., 2013). Along these lines, several studies empirically analyze the effect of external knowledge sourcing on innovation performance (Morris et al., 2004; Cassiman and Veugelers, 2006; Ayuso et al., 2011).

However, the results show that the effect of external knowledge sourcing on innovation is far from direct, in fact is contingent on numerous factors. For instance, Laursen and Salter (2006) defend that innovation can be determinant of firms' levels and types of external knowledge search. Others explain the role of firms' internal capacities and their relevance for exploiting external knowledge sources (Cohen and Levinthal, 1989; Cohen and Levinthal, 1990; Cassiman and Veugelers, 2006; Tsai, 2009). This capacity, first coined by Cohen and Levinthal (1990), has been known as absorptive capacity, that is, the firms' ability to recognize and assimilate new external knowledge, and apply it to commercial ends.

Using absorptive capacity as their main theoretical framework, the majority of these studies examines internal capacities through research and development (R&D) and rather ignores the role of the firm's coordination mechanisms (Lane et al., 2006; Colombo et al., 2011). Coordination mechanisms (formalization of organizational processes and decentralization in the decision-making processes) facilitate the sharing of external knowledge thereby creating the necessary conditions for its ultimate utilization (López and Esteves, 2011). The absence of studies about coordination mechanisms is somewhat surprising considering that Cohen and Levinthal's theoretical framework includes this reasoning in their conceptualization of absorptive capacity.

The aim in this paper is to contribute to external knowledge sourcing research by analyzing the role of coordination mechanisms in the exploitation of external knowledge. We argue that R&D is not enough to explain the process through which external knowledge is eventually exploited and that coordination mechanisms also play a part and provide a better understanding of the phenomenon.

We draw on organization theory, which proposes that coordination mechanisms, which lie behind the learning processes through which knowledge is created, integrated and utilized are determinant for innovation (Hult et al., 2004; Ayuso et al., 2011; Pérez-López and Alegre, 2012). Moreover, studies within this tradition have recognized that coordination can facilitate the attainment of either exploratory or exploitative innovations (Jansen et al., 2006; Chang and Hughes, 2012). However, organization theory focuses on the role of coordination mechanisms in leveraging internal knowledge for innovation and pays little attention to the role in this process of external knowledge (Song et al., 2005). This line of work has evolved in parallel but with no direct connection to the external knowledge sourcing literature (Colombo et al., 2011).

This study intends to bridge across these two bodies of literature, organization theory and external knowledge sourcing research, in order to disentangle the role played not only by R&D but also by the firm's coordination mechanisms, in shaping the ultimate exploitation of external knowledge. In addition, the study adds to both streams of the literature by showing possible differences in external knowledge exploitation when considering exploratory or exploitative innovations. The study uses data on the Spanish ceramic tile industry.

The paper is organized as follows: Section 2 and 3 presents the theoretical framework for this investigation and the proposed hypotheses. Section 4 discusses the reasons for the empirical research, and describes the sample, the measurements used and the econometric specification. Section 5 describes the analysis and presents the results. Section 6 suggests conclusions from the study, limitations and possibilities for further research.

## Conceptual Background Innovation performance and its determinants

Innovation has been captured in different, sometimes quite elaborate ways. The most common differentiation is between product and process innovation (Damanpour, 1991; OECD-Eurostat, 2005). Following March's (1991) seminal piece, exploration and exploitation innovations have also been used to capture types of innovative results. Exploitative innovations are principally based on highly related knowledge areas and are directed to satisfying current market demand; exploratory innovation employs more distant knowledge and is aimed at future demand (Benner and Tushman, 2003; Jansen et al., 2006).

From this literature we learn that exploratory results generally requires of distant knowledge from that of the firm's knowledge base (Zhou and Li, 2012). Moreover, to integrate

distant knowledge in the firm's knowledge stock more internal resources are required in order to enable its correct assimilation and exploitation. Thus, the development of a strong technological knowledge base assists the process of searching in new technological arenas and strengthens the firm's capacity to achieve exploratory innovations (Rosenkopf and Nerkar, 2001; Zhou and Wu, 2010). In general, this literature emphasizes that the development of strong internal technological base, through R&D activities, can lead to more exploratory solutions.

Moreover, the coordination of multiple organizational activities has been also advanced as essential for managing knowledge and learning, and pursuing innovation results. One way to enhance coordination is through the use of coordination mechanisms, including decentralized decision-making and formalization of organizational processes (Jansen et al., 2006). The former refers to the extent to which the locus of authority and decision-making extends down the hierarchical layers in the organizational structure (Damanpour, 1991), the latter describes the degree to which behaviors are programmed by formal rules and procedures (Khandwalla, 1977).

Studies in this tradition have continuously described formalization and decentralization as opposing forces where formalization satisfies better the development of exploitation and decentralization fits better exploration (Jansen et al., 2006; Chang and Hugues, 2012). In this sense, decentralization of decision-making promotes autonomous decision-making and the capability of generating new ideas and discovering new solutions (Cohen and Levinthal, 1990; Menguc and Auh, 2010). Moreover, providing employees with autonomy to make their own decisions contributes in a positive manner to the creation of a participatory work environment, which enhances organizational members' awareness, commitment and involvement in the creation of novel knowledge (Damanpour, 1991; Song et al., 2005).

In the case of formalization of organizational processes, the literature generally agrees about the pervasive effects of institutionalized rules and procedures, on exploratory innovation. It stresses that organizations that are highly formalized inhibit the spontaneity, creativity, risk-taking and experimentation among employees that are needed for knowledge creation (Bidault and Cummings, 1994; Menguc and Auh, 2010). Formalization does not allow deviation from established rules, and results in highly inflexible structures. Rigidities inhibit knowledge flows within the organization reducing the firm's capabilities to experiment and obtain exploratory results (Benner and Tushman, 2003). Finally, as organizations increasingly program tasks, employees feel less inclined and motivated to create new knowledge (Willem and Buelens, 2009).

## External knowledge sourcing and innovation

Recent trends reflect the exposure of firms to the exterior world, and the progressive opening of traditionally hermetic organizational boundaries. Several economic theories related to innovation stress the role of external knowledge as increasingly essential (Breschi and Malerba, 1997; Baptista and Swann, 1998). For instance, the open innovation approach suggests that an important number of firms have shifted to an innovation model characterized by high levels of 'openness' and a wide range of external sources to provide a basis for the achievement of innovation (Chesbrough, 2003; Rass et al., 2013).

The reasons why external knowledge is required for innovation are numerous. The external search for knowledge is often driven by the need to access complementary assets as inputs in the firm's race towards innovation. Sometimes firms are looking to reduce risks by sharing the costs of R&D with other agents (Miotti and Sachwald, 2003; Belderbos et al., 2004). Also, working with external agents may foster the transfer of tacit knowledge resulting in the generation of resources that would have been difficult to obtain without such interaction (Ahuja, 2000; Das and Teng, 2000).

Studies in this tradition have analyzed the effects of external knowledge sourcing on innovation (Morris et al., 2004; Lin and Wu, 2010; Ayuso et al., 2011). In particular, the notion of absorptive capacity has emerged as a conceptual approach to complement studies analyzing external knowledge sourcing and its effect on innovation results. This approach emphasizes that the firm's internal efforts to create new knowledge not only enhance the firm's innovative performance but also increase the firm's ability to exploit external knowledge sources in the development of new products (Cohen and Levinthal, 1990; Zeng et al., 2010).

## Hypotheses

Several works have analyzed the effectiveness of external knowledge sourcing taking account of the role played by R&D activities. Most of these studies have shown a complementarity relationship between the enhancement of R&D and external knowledge acquisition (Miotti and Sachwald, 2003; Cassiman and Veugelers, 2006; Tsai, 2009; Tsai and Wang, 2009; Sofka and Grimpe, 2010). Moreover, when outside knowledge is less targeted to the firm's particular needs and concerns, a firm's own R&D becomes more important in recognizing and exploiting its value (Cohen and Levinthal, 1990; Zhou and Wu, 2010). In this sense, the accumulation of scientific and technological knowledge allows firms to experiment beyond current technological knowledge boundaries and therefore increase the firm's ability to produce exploratory innovation. Hence, we hypothesize that:

H1: R&D positively moderates the relationship between external knowledge acquisition and firm's innovation performance, especially in the case of exploratory innovations.

As firms are forced to look beyond their boundaries in their search for knowledge, transmitting, receiving and processing external information efficiently and effectively is very relevant. Decentralized decision making speeds up the external knowledge sourcing process by reducing the need to continually report back to a higher authority (Galbraith, 1974; Foss et al., 2011). Empowering employees increases their knowledge absorption capabilities and the possibility of discovering new solutions (Cohen and Levinthal, 1990). The motivational element is important for engaging employees in the search for knowledge within the organizational boundaries (Damanpour, 1991) and also for knowledge searching beyond them. Thus, delegation of responsibility and the active participation of employees in decision-making could facilitate the processes that enable the exploitation of external knowledge. Moreover, we argue that the positive effect of decentralization on external knowledge exploitation can be increased in the case of exploratory innovations. The achievement of exploratory innovations needs of higher integration knowledge efforts (Zhou and Li, 2012). Following this line of reasoning, we argue that the empowerment of employees enhances knowledge sharing and communication leading to more exploratory results. Hence,

H2: Decentralization in decision-making positively moderates the relationship between acquisition of external knowledge and firm's innovation performance, especially in the case of exploratory innovations.

Formalization also matters for external knowledge sourcing processes. Formalized practices tend to reinforce work processes and limit employee's freedom to deviate from established procedures (Benner and Tushman, 2002; Benner and Tushman, 2003). In this sense, the potential of employees to search for new ideas and in particular, to be externally oriented and respond to crisis situations can be highly diminished (Vega Jurado et al., 2008a). In this sense, formalization through the imposition of rigid structures reduces knowledge flows hampering the ultimate exploitation of external knowledge. Formalization also reduces employees' motivation to explore for new knowledge (Willem and Buelens, 2009), negatively influencing the effect of external knowledge sourcing on innovation. To sum up, formalization of organizational processes disallows the greatest benefit from external knowledge. Moreover, we argue that the expected detrimental effect of formalized procedures on innovation can be increased in the case of explorative results due to their pervasive effect on creativity, flexibility and the necessary inputs for achieving exploratory innovations. Hence,

H3: Formalization negatively moderates the relationship between acquisition of external knowledge and innovation performance, especially in the case of exploratory innovations.

## Methods - Sample

Studies in the industrial economy tradition show that innovation differs across sectors in terms of its characteristics, sources, relationships among actors, and the boundaries to the process (Malerba, 2005). In this respect, several studies show that the incentives to search beyond organizational boundaries varies across industries and depends on their levels of technological opportunities and appropriability conditions, among other characteristics (Klevorick et al., 1995).

To effectively isolate the disturbance arising from industry differences, this research focuses on one specific sector in Spain: the ceramic tile industry. This sector tends to be geographically concentrated in industrial districts. For this reason firms in the sector establish more links with external agents such as research institutes, regional universities, and suppliers (Alegre et al., 2004). In our view, this makes the ceramic tile sector especially appropriate for our analysis due to the relevance of external knowledge in the configuration of firm's innovation strategies. It provides a clear illustration of development, acquisition and exploitation of external knowledge (Alegre and Chiva, 2008; Petruzzelli et al., 2009). Our data were collected through a survey in 2011 directed to ceramic manufacturers. The survey was administered by recruited trained interviewers, who conducted onsite interviews in order to generate valid information and high-quality data. The questionnaire was addressed to the manager in charge of R&D. The questionnaire was pretested to ensure that the questions were clear and understandable.

Our target population was the 132 ceramic tile manufacturers. The response rate was 80%, which is very high (Alegre and Chiva, 2008). After eliminating cases of missing data the final sample included 98 firms. Several scholars warn about common method bias in self-reported data. To analyze the extent of this problem we applied a Harman's one-factor test; the results were satisfactory (Podsakoff and Organ, 1986).

## Measures

Studying a single industry makes exploration and exploitation an appropriate distinction to capture the multiple features of innovation outcomes. To construct our dependent variables we used the responses to the question about the degree of intensity of several innovation results taking place in the firm on a scale of 1 (low intensity) to 3 (high intensity).

This indicator is based on the Oslo Manual (OECD-Eurostat, 2005). Following the classification proposed by Jansen et al. (2006) we grouped these results into exploration and exploitation. Hence the effects of exploratory innovations are measured along three dimensions: (i) degree in which the firm has identified new markets; (ii) degree in which the firm has accessed new markets; and (iii) exploration of new technological areas. On the other hand, the effect of exploitative innovations was measured along the dimensions of: (i) quality improvement to a good or service; (ii) reduction in costs of production; (iii) improved production capacity; and (iv) greater user satisfaction. The Cronbach's alpha ( $\alpha$ ) for both constructs is 0.74 indicating that the items in the index are reliable. Based on these results we created two constructs by calculating the mean of the corresponding items.

Conceptualization of external knowledge sourcing differs. There is a stream in the literature that discriminates between the mechanisms used to acquire external knowledge (cooperating, licensing, contracting R&D...), and another stream that focuses on the nature of the partner or knowledge provider involved in the process, such as suppliers, clients, competitors, universities... (Lam and Chua, 2009; Wilhelm et al., 2013). Studies in this area usually employ general questions to extract information on the existence of a relationship with external agents or the involvement of the firm in particular mechanisms, as indicators of external knowledge sourcing activity. In this study we use the mechanisms for acquiring external knowledge (OECD-Eurostat, 2005). Specifically we consider whether the firm uses external R&D, acquisition of machinery and equipment, acquisition of hardware and software, acquisition of additional external knowledge, training or consulting. The Cronbach's alpha ( $\alpha$ ) is 0.85 indicating that the items forming this index are reliable. Following Laursen and Salter (2006) we are interested in the breadth of external knowledge sourcing and consider the number of mechanisms used by firms to acquire knowledge from external sources. Thus, we created a construct integrating the questions related to the sum of the different mechanisms used. The final variable was calculated by grouping the value of external sourcing into: 0 if the firm used no mechanism, 1 if the firm used 1-3 mechanisms and 2 if the firm used 3-6 mechanisms. This is an ordinal scale of the breadth of the firm's external knowledge sourcing activities. We use percentage of employees dedicated to internal R&D to proxy for the firm's R&D activities (Artes, 2009; Keupp and Gassmann, 2009). This measure was chosen because the percentage of employees is a more stable indicator than total R&D expenditure over sales, which can show wide variations. For instance, a firm could decide to make a one-off purchase of expensive equipment, or might have higher sales fluctuations in a specific year for a variety of reasons. Another rationale for choosing this measure is that employees are more strongly related to tacit knowledge and experience (Muscio, 2007).

Formalization and delegation of decision-making are central to the firm's coordination mechanisms (Jansen et al., 2006). For the case of formalization, respondents were asked whether the firm's norms and established procedures were systematically followed by the organization. This question was designed to capture to what extent rules and procedures occupied a central place in the organization. For the case of decentralization, we asked whether working teams had autonomy for decision-making in order to capture the extent to which employees are encouraged to use initiative. In both cases, the responses were scored on a Likert scale from 1 (totally disagree) to 4 (totally agree).

The research model includes firm size, firm age and group as controls for possible confounding effects. The Schumpeterian hypothesis argues that large firms have an innovation advantage over smaller firms in terms of output, because firm size affects the endowment of important inputs to the innovation process, the achievement of economies of scale in R&D, and the ability to spread risks over a portfolio of projects (Cassiman and Veugelers, 2006). Thus, small firms cannot risk "betting on the wrong horse", but large firms can afford to run multiple projects which increases their chances of effective exploitation of external knowledge (Schmidt, 2010). In the analysis we control for the effect of firm size by including the natural logarithm of the total number of employees.

Previous studies show that firm age affects innovation. On the one hand, older firms have more experience than newer firms, which may be positive for innovation (Sorensen and Stuart, 2000). On the other hand, there can be negative effects of older age. As firms mature they have a higher possibility of becoming more dependent on routines, becoming inflexible and rigid, which deters innovation (Hannan and Freeman, 1984). Thus, we control for number of years since the firm's foundation.

The final control is an indicator for belonging to a group. Firms that are part of a group may show different behavior in relation to innovation results. They may have more opportunities to access additional resources that can be used to achieve innovation (Vega-Jurado et al., 2008b). In order to measure the dependency of the firm on a group we use a dummy variable that takes the value 1 if the firm interacts with the group and 0 otherwise. This goes beyond traditional measures that provide information only about membership or not of a group; our measure indicates interaction between the firm and the group indicating access to and acquisition of resources.

## Statistical Analysis and Results

Table 1 presents the descriptive statistics and the bivariate correlations. Table 1 shows that the majority of firms acquires external knowledge. A more detailed analysis of the variable distribution shows that 8.6% do not use any external search mechanism, 19% of firms pursue between 1 and 3 search mechanisms and 73.3% use 3 to 6 different mechanisms. The behavior of this variable reflects that the majority of ceramic firms acquire knowledge through multiple activities ranging from the acquisition of R&D to the contracting of consulting services (for more detail see Table 2).

In the case of firms' R&D activities, the percentage of employees dedicated to R&D activities rises to 4.71%. Compared to the proportion for the whole of the Spanish manufacturing industry, which is 2.98% (INE- Spanish National Statistics Institute-, 2010) the ceramic industry dedicates on average almost 50% more employees to R&D activities. For

decentralization of decision-making and formalization, this behavior is fairly widespread especially formalization.

We find that the independent variables are not highly correlated. We calculated variance inflation factors (VIFs) and the maximum value was 1.95, which is below the rule-of-thumb of 10 (Neter et al., 1996). These indicators indicate that there are no multicollinearity problems.

Table 3 presents the results of the regressions for the effects of innovation, taking account of the categories of exploitation and exploration. Our hypotheses are tested using standard ordinary least squares (OLS) regression techniques. The first two models in the table present the main effects and the controls for our explanatory variables; the last two models are concerned with the interaction effects. Interaction effects were created by multiplying together the main variables and standardizing them to reduce potential multicollinearity problems.

Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5	6
1. Acquisition of external knowledge	1.65	0.64	0	2						
2. Internal R&D	4.71	7.28	0	60	0.11					
3. Decentralization of decision-making	2.72	0.89	1	4	0.27**	0.05				
4. Formalization	3.17	0.70	1	4	0.05	-0.03	0.03			
5. Size	4.31	0.87	1.61	6.62	0.43**	0.05	0.38**	0.00		
6. Age	27.50	13.96	6	62	0.18*	-0.01	0.13	0.13	0.31**	
7. Group	0.35	0.48	0	1	0.19*	0.17*	0.08	0.02	0.31**	0.12

Table 1: Descriptives and pearson correlation coefficients. \* $p < 0.10$  \*\* $p < 0.05$

	Frequency	Percentage
External R&D	81	77.1
Acquisition of machinery and equipment	81	77.1
Acquisition of hardware and software	81	77.1
Acquisition of additional external knowledge	71	67.6
Training	87	82.9
Consulting	80	76.2
Total	105	100

Table 2: Number of firms using specific external knowledge mechanisms

Overall, our models present high  $R^2$  values, indicating that an important part of the variance is explained. Model 1 explains 42% of the variance, and this increases by 8% when the interactions terms are included (Model 3). Model 2 explains 40% of the variance and increases to 5% when the moderator effects are considered (Model 4). The results show that the changes in  $R^2$  are highly significant indicating that it is appropriate to introduce moderator effects in our model.

The results related to the main effects (Model 1 and Model 2) reveal that acquisition of external knowledge has a strong influence on both exploratory and exploitative innovation outputs. This result is in line with much of the innovation literature, which underscore the importance of external knowledge sourcing for innovation (Chesbrough, 2003; Cassiman and Veugelers, 2006). Moreover, in the case of ceramics we can explain and characterize the results of our analysis. In the ceramic tile industry suppliers are the main drivers of industry innovative behavior. In particular, suppliers of equipment are the key actors in the process of producing ceramic tiles. We believe that an important part of machinery sourcing is strongly related to enhancing the firm's productive capabilities and explains the strong effects on exploitative innovation. Acquisition of external knowledge also exerts a strong influence on exploratory innovations. In this case, suppliers of frits and glazes and scientific institutions (such as universities and research institutes) are important sources of R&D services in the district. These agents generate the relevant knowledge, skills and techniques described in academic research. This type of knowledge is considered distant from the firm's knowledge base and not immediately applicable to ongoing activity. However, it is used for experimentation, exploration of new technological areas and disruptive innovation.

In the particular case of exploratory innovations, certain internal capabilities, such as R&D and decentralization in decision-making are also significant. This confirms that exploratory innovations are more dependent on internal R&D activities and decentralization of decision-making. This is in line with Jansen et al. (2006) study which shows that centralization in decision-making is detrimental to exploratory innovation. Size is the only control variable that appears significant reflecting that bigger firms, because of their greater access to additional resources, are at an advantage when pursuing innovation.

We analyzed the moderating effects in order to answer our research questions. Our study shows that R&D activities are important moderators of acquisition of knowledge and innovation, for both exploitation and exploration. In this sense, we can accept H1. This study also confirms that coordination mechanisms make a difference in this process and is line with our general claim regarding the necessity to

incorporate them into knowledge sourcing analyses. In the case of decentralization of decision-making the relationships are not significant, so we can draw no clear conclusions from results of H2. Possibly, as other authors have argued decentralization could be relevant for the initial generation and sharing of new ideas but not so determinant in the final phase of knowledge exploitation (Jansen et al., 2005). In the case of formalization our results support H3. They show a negative effect of formalization on the exploitation of external knowledge, in the case of exploratory results.

## Discussion

This study analyzed the role of R&D and coordination mechanisms as important moderators in the process involving the acquisition of knowledge and its ultimate conversion into innovation results. In addition, this study considered the differences involved in the management of knowledge when innovations are directed towards exploration or exploitation aims. Specifically, the empirical study was performed in the context of the Spanish Ceramic Tile industry. Interestingly, the wide range of actors that interact with ceramic manufacturers makes this sector suitable to analyze how firms take advantage from inter-organizational knowledge.

In line with studies highlighting the increasing tendency of firms to search outside for knowledge, our results support that external knowledge sourcing is a generalized strategy (Cassiman and Veugelers, 2006; Ayuso et al., 2011). We suggested that the acquisition of knowledge beyond organizational boundaries is fundamental for innovation efforts. Moreover, our results confirm that the acquisition of external knowledge contributes not only to the refinement and extension of existing competences and technologies but also to experimentation with new alternatives.

Moreover, our results reveal that this relationship is moderated by coordination mechanisms. Thus, drawing on organization theory we integrated into the analysis decentralization of decision-making and formalization of organizational processes as important mechanisms enhancing the firm's capacity to integrate external knowledge into the pool of the firm's existing knowledge. Our results show that these mechanisms exerted different effects in the final exploitation of external knowledge. In particular, while decentralization of decision making positively but not significantly moderated knowledge acquisition and innovation, formalization clearly exerts a strong significant and negative effect.

Specifically, our results show that formalization is a barrier to the utilization of external knowledge for exploratory innovation. Exploratory innovation is usually associated with disruptive results based on knowledge unrelated to the firm's knowledge base. The fact that such innovation builds

	Main effects				Interaction effects			
	Exploitative		Exploratory		Exploitative		Exploratory	
	Innovation		Innovation		Innovation		Innovation	
	Model 1		Model 2		Model 3		Model 4	
	b	t	b	t	b	t	b	t
Constant	0.90***	3.53	1.15***	4.09	0.81***	3.27	1.11***	3.95
Acquisition of external knowledge	0.27***	2.95	0.23***	2.44	0.33***	3.11	0.29***	2.67
Internal R&D	0.04	0.52	0.17**	2.00	0.24***	2.50	0.29***	3.08
Decentralization	0.07	0.75	0.22***	2.50	0.08	0.97	0.21***	2.40
Formalization	-0.06	-0.76	-0.05	-0.63	-0.13*	-1.67	-0.10	-1.19
Size	0.41***	4.02	0.34***	3.28	0.44***	4.44	0.34***	3.36
Age	0.04	0.50	-0.01	-0.13	0.06	0.68	0.00	-0.03
Group	0.05	0.54	-0.03	-0.27	0.03	0.36	-0.05	-0.58
Acquisition of external knowledge x Internal R&D					0.34***	3.31	0.20***	1.92
Acquisition of external knowledge x Decentralization					0.00	0.03	0.07	0.71
Acquisition of external knowledge x Formalization					-0.13	-1.59	-0.17***	-1.92
R <sup>2</sup>	0.42		0.40		0.50		0.45	
Change in R <sup>2</sup>	0.42		0.40		0.08		0.05	
F for change in R <sup>2</sup>	9.42***		8.85***		4.55***		2.61**	
F for model	9.42***		8.85***		8.73***		7.30***	
Number of observations	98		101		98		101	

Table 3: Ordinary least squares regression results: predictors of innovation performance  
 \*p<0.10 \*\*p<0.05 \*\*\*p<0.01



on distant and novel knowledge implies the need for greater creativity, which is less likely with formalization in place. Formalization creates rigid inflexible structures, which are a barrier to the integration of knowledge flows and ultimately hinder the transformation of external knowledge into innovations results. The imposition of formalized procedures can also affect employee motivation by reducing their autonomy to engage in creative and novel solutions. In this sense, the negative moderating effect of formalization on acquisition of knowledge and innovation is even more relevant in the case of exploratory innovation.

The present study confirms the joint effects of external knowledge acquisition and scientific and technological knowledge generation in terms of higher exploitative and exploratory innovation. This result is in line with Cohen and Levinthal's (1990) conceptualization of the second face of R&D. In this perspective, R&D is considered not only to generate innovation but also to enhance the firm's ability to identify, assimilate and exploit knowledge from the environment, that is, to increase the firm's 'learning' or 'absorptive' capacity. Specifically, our results show that this logic applies to both exploratory and exploitative innovations. R&D is a too broad measure; it includes different activities, culture, management and other features (Barge-Gil and López, 2012). Thus, probably knowing the orientation of R&D would help us to explain better this relationship.

Previous work explaining firm success in exploiting external knowledge focus on R&D activities. Our results show that not only is R&D important, but coordination mechanisms also matter. Also, these results show that the influence of coordination mechanisms on the exploitation of external knowledge can be positive or negative depending on its nature. Our study shows that formalization inhibits the firm's capacity to coordinate divergent areas of knowledge within the organization. Finally, our results demonstrate that the moderating effect of coordination mechanisms between external knowledge sourcing and innovation is contingent on the type of innovation results.

This work has some practical implications for managers. In current complex environments, the role of external knowledge and its influence on innovation is becoming increasingly important in corporate decisions. Managers need to understand that both R&D activities and the implementation of certain coordination mechanisms are required to leverage external knowledge to become successful innovation.

Our study also has some limitations. First, it is based on responses to a questionnaire; perceptual measures and single-source responses are a limitation because common method bias cannot be totally ruled out. Second, results are based on cross-sectional data avoiding the inference of causality

relations. Third, even though analyzing one sector has the advantage of making sure that external knowledge acquisition patterns are not due to sector differences, results cannot be directly interpreted for other sectors. Thus, in the future a multi-sector analysis would be recommendable.

Also, future research could focus on additional dimensions of external knowledge sourcing, such as the agents involved (universities, suppliers etc) or the depth dimension of the external search. Deepening into the recent discussion involving new organizational forms could provide this study with additional insights. All in all, this would enrich debate on the role of firm's organizational configurations in the transformation of external knowledge into innovation results.

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